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An Optimization Model of Banking Outlets Integration Based on the Network Comprehensive Analysis

Yong Wang, TA Zhou
Department of Computer Zhangjiagang, Jiangsu University of Science and Technology
Zhangjiagang Campus, 215600 Jiangsu China
email: jkd_wangyong@126.com, zhouTa@hotmail.com

Abstract

The distribution of real banking outlets is based on the establishment of branches according to administrative division, which is obviously not rational in distribution. Against this phenomenon, this paper first analyzes the major factors that affect the distribution of outlets. Then, based on complex network, it puts forward the distribution model of outlets. Finally, it analyzes the model. At the same time, the paper takes the banking outlets of China Construction Bank of Wuxi City, Jiangsu Province for example. It employs the model to distribute and integrate its banking outlets. As a result, the distribution after integrating is more rational than the previous distribution, which verifies the rationality of the model and the distribution method of banking outlets.

Keywords*: Complex network, distribution of banking outlets, integration of banking outlets*

1. Introduction

Financial market has been fully opened to foreign investment since China's entry into WTO. This has brought forth unprecedented challenges to the banking sector. Currently, blind and repeated construction of banking outlets is a universal phenomenon. On one hand, some people have neglected scientific planning; on the other hand, unreasonable decision-making has resulted in wastage of resources and extremely low operation efficiency of banking outlets. Therefore, it is an urgent task to study the distribution of banking outlets. How to take into full consideration of distribution of banking outlets in a certain city to ensure maximum economic and social benefits of banking outlets in a society of enormous information? Under such circumstance, it is necessary to proceed with comprehensive and systematic study and integration of the whole outlets with scientific optimization method [1-2].

Location Theory and Central Place Theory are two representative theories for distribution of banking outlets. Normally, investor or user prefers to select the location of the minimum total cost, namely the place of the minimum sum of land rent and cumulative transport cost. Location Theory serves as the doctrine on distribution of space for human activities and mutual spatial relationship. More specially, it is a theory on selection of spatial location for human economic behavior and optimal integration of economic activities within the spatial location. Central Place Theory was put forward by W.Christaller, the German urban geographer and A.L & ouml; sch, the German economist respectively in 1933 and 1940. It became popularized in U.K in 1950s, which was spread to other countries later. It is deemed to be one of the most important contributions to human geography in this century, which serves as one of the basic theories for study of urban agglomeration and urbanization. Moreover, it is also a city location theory for exploration of the optimal urban system as required by study of urban space organization and arrangement [3-4].

Presently, study on distribution of banking outlets at home is so limited. Zhang Mengfang inquired into the features of existing distribution of banking outlets in 1997, and proposed that establishment of branches in reference to administrative division might result in low work efficiency and repeated establishment of banking outlets. On this account, she put forward the opinion on distribution of banking outlets according to economics of scale and decreased hierarchical management. In the same year, Zhang Dexiang carried out comprehensive analysis of various factors affecting the distribution of banking outlets, and proposed marginal formula for increment of banking outlets and numerical treatment approach

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from the angle of input and output. In 2002, Ji Yingying divided the urban area into hot-spot area, prosperous area, potential area, undeveloped area and declined area, and proposed that banking outlets ought to be established in the prosperous downtown area and urban trunks [5-7].

In 2003, Xi Junyang proposed that construction of distribution channel was an important link in the configuration of banking outlets. In the same year, Tao Jun put forward the opinion that banks were in a transition to human-machine conversation accompanied by appearance and application of ATM, and conventional distribution of banking outlets was to be overturned. Yang Xianghua studied the distribution of outlets of Agricultural Bank of China Guangzhou Sub-branch [1] with GIS technology; whereas Li Feng and his colleagues proposed to establish outlet optimization model based on the conception of complex network, and proceed with analysis of the model and adjustment of outlets. However, he only targeted at the individual bank, and took optimization of distribution of an individual bank as the objective. He indicated the linear distance between two outlets over and below the sum of service radius with 0 and 1 respectively, and thereby obtained the adjacency matrix for analysis. However, the neglected the integrity of the network [3]. Similarly, Chen Xi and his colleagues managed to ensure the minimum uncovered area and optimal distribution under certain economic conditions through establishment of a mathematical model for the distribution of receiver with insert and radiation methods according to coverage of vehicle alarm receiver in downtown area [4, 8-10].

On the contrary, there are numerous studies on the distribution of banking outlets abroad. In 1989, Halland, Mcgee, Cross and Goldbe carried out comprehensive analysis of the quantity of foreign banks among banks in U.S.A and their impact on the scale of financial sector in U.S.A. In 1980, Gold Begansaunters analyzed the main factor for U.K to make its way into U.S.A banking industry, and proposed that the commercial intercourse between the two countries was the most important reason. In 1990, they inquired into the main reason for the impact of Bank of America on the distribution of banking outlets in U.S.A, and arrived at the conclusion that it was the direct investment FDI [3, 11-12]. Analysis of factors affecting distribution of banking outlets.

Distribution of banking outlets is an important and complicated task, which should be in consideration of natural, social and economic factors. Commercial features of outlets serve as the specific start point. It is necessary to consider population composition, conditions of public service utilities, traffic conditions and social factors in case of selection and establishment of banking outlets. Meanwhile, it is also necessary to consider significant difference to the economic development level in different period of time [5].

Factors affecting distribution of banking outlets are generally divided into continuous and discrete types. Continuous factors refer to factors that only impose impact on the location of certain outlet, such as population. Such factors can be easily handled through distribution of geographic location and dimension as per the area ratio.

Discrete factors refer to factors that are divergent to the location, such as station and street. Action range and influence degree of such factors are indefinite, of which influence scale is jointly determined by the area center and distance of facilities. Conventional site selection for banking outlets is carried out with the following several methods:

- Heuristic method: It is a method for gradual obtainment of approximate solution, namely rough initial solution in reference to the model to obtain the final optimal solution through repeated iterative correction. Normally, such method is only in consideration of several factors affecting the distribution of banking outlets other than full consideration of mutual relationship between each outlet.
- Analogy method: This method is a process for obtainment of dynamic system model with numerical method. It aims to proceed with gradual solution from initial status according to practical progress to obtain a special solution to the model eventually. Such method lays emphasis on practical simulation, which can accurately simulate operation environment of the facilities. Furthermore, it requires long-time simulated operation to determine the site selection proposal.
- Optimization method: It is a method used to indicate factors affecting site selection with mathematical formula, and seek the optimal point within the possible solution range in reference to the restricted scope. Such method is frequently used at present. For instance, linear planning is a conventional optimization method.

Aforesaid research findings have analyzed some problems with the distribution of banking outlets, and proposed some methods for distribution and optimization. It is obvious that such methods also have defects despite of the fact that they play an extremely important role in study of distribution of banking outlets: Such models might be divorced from reality, which are unlikely to fully consider such complicated factors and mutual impact between each element, and proceed with comprehensive processing of relevant complicated data. Liu Zongwei has carried out integration and optimization of banking outlets as well as comprehensive analysis and study of practical conditions based on GIS (geographic information system) and neural net method. Meanwhile, he has also managed to provide decision-making personnel with some reasonable and valuable information. However, data acquisition is a bottleneck to this method. With regard to study of distribution of banking outlets at present, scholars at home and abroad mainly focus on financial geography and main factors affecting the distribution other than study of distribution of banking outlets with the help of network.

Study of complex network in the academic circle has reached its climax. In particular, two ground-breaking tasks in the world have further stimulated the craze for study of complex network. Firstly, Watts and Strogatz published an article on Nature [6] in 1998 to describe the transition from completely regular network to completely stochastic network through introduction of Small-World network model. Small-World network has the clustering characteristics similar to the regular network in addition to the smaller average route length similar to the stochastic network. Secondly, as pointed out by the article published by Barabási and Albert on Science in 1999, connectivity distribution of numerous practical complex networks is in the power-law form. As power-law distribution is free of obvious characteristic length, such network is also called Scale-Free network [7].

2. Construction, Application and Empirical Analysis of Model

2.1 Features of Complex Network

Normally, complex network is provided with the following features:

2.1.1 Degree and Degree Distribution

The degree is defined as the number of adjacent sides of the node, which can be indicated as

$$k_i = \sum_j a_{ij} = \sum_j a_{ji} \tag{1}$$

Average degree is defined as:

$$< k >=< k_i >= \frac{1}{N}\sum_i k_i = \frac{1}{N}\sum_{ij} a_{ij} \tag{2}$$

Degree distribution $P(k)$ is defined as a random node, of which degree is just the probability k [8].

2.1.2 Cluster Coefficient (Statistical Description of Three Rings or Three Complete Graphs)

Cluster coefficient aims to describe the proportion of two adjacent nodes in the network, namely the perfection of the small-group structure.

Cluster coefficient of the network is indicated as: $C = \frac{3N_\Delta}{N_3}$, in which $N_\Delta = \sum_{k>j>i} a_{ij}a_{jk}a_{ik}$ refers to the sum of triangle in the network (three rings or three complete graphs);

$N_3 = \sum_{k>j>i}(a_{ij}a_{ik} + a_{ji}a_{jk} + a_{ki}a_{kj})$ refers to the sum of “triads” in the network (namely the triangles in which one side missing); refers to the matrix element of adjacent matrix in the network [8].

2.1.3 The Shortest Route

The shortest route is defined as follows: The apex selected as the start point is called the source point; whereas another apex as reached via one side of the graph is called the final point; select one route among numerous routes as passed to make sure that the sum of weight value of each side along this route is the minimum.

2.2 Regulations on Distribution Network of Banking Outlets

Distribution of banking outlets is an important and complicated task; whereas reasonable adjustment of the distribution involves numerous factors. To facilitate study of problems, this model is regulated as follows:

This model aims to proceed with study and adjustment by taking each administrative district as the unit, and take the maximum utilization of resources of banking outlets within the district as the objective for study.

With regard to the banking outlets at the junction between each district, this paper prefers to increase outlets within the area where the junction outlets of smaller inclination situate. Nevertheless, it is appropriate to give priority to self-service equipments. This can effectively guard against the phenomenon of “the rich get richer; whereas the poor get poorer”, and ensure the maximum service and profits of the banking outlets.

Economic and social conditions of each district are different; whereas economic and social conditions at various aspects in each district are also varied. To facilitate study of problems, this paper assumes that economic and social conditions of each district are the same.

This paper assumes that the each banking outlet has equal standing and its own covered area. Supposing that the covered area is a circle, the radius of this circle is called covering radius.

2.3 Model Establishment

Firstly, this model involves field density. The so called field density refers to the number of outlets per kilometer within the administrative district, which is indicated with ρ in this paper.

Secondly, as the dimension of service area R is in inverse ratio with local economy, population density and balance of saving deposits in urban and rural areas at the year end, covering radius r of any outlet in each district is defined as:

$$\frac{R}{r} = \frac{A_i \times B_i \times C_i}{A \times B \times C} \tag{3}$$

in the formula, A_i refers to GDP per capita in the administrative district I; A refers to GDP per capita in the said district; B_i refers to the population density of the administrative district I; B refers to the population density of the said administrative district; C_i refers to the balance of saving deposits in urban and rural areas at year end of the administrative district I; C refers to the balance of saving deposits in urban and rural areas at year end of the said administrative district.

Thirdly, average covering radius $\bar{r}$ of the network is obtained based on aforesaid assumption in addition to the formula $\bar{r} = \frac{S}{\sum_{i=1}^{n} \rho_i \times S_i}$; in the formula, ρ_i refers to the density of the district i; S_i refers to the area of the district i; n refers to the quantity of districts.

Fourthly, if the sum of the covering radius between any two outlets is less than the average covering radius $\bar{r}$ of the whole network by 2 times, namely $r_i + r_j > 2\bar{r}$, it indicates that areas covered by the two outlets are intersected; the covered area in the adjacent matrix is indicated with 1; otherwise, it is indicated with 0. In this way, the adjacent matrix of the network as formed by the banking outlets is obtained.

Finally, proceed with processing and analysis of adjacent matrix as obtained with the help of aforesaid model with NetDraw software, a social network analysis and visualization tool, to further obtain topological graph for the corresponding network. After that, further calculate network degree and statistical features of clustering coefficient to realize integrated distribution of banking outlets through analysis.

3. Model Application and Empirical Analysis

This paper aims to analyze the distribution of banking outlets of China Construction Bank Jiangsu Branch Wuxi Sub-branch, and find out unreasonable parts for integration based on the established model.

3.1 Analysis of Economic Conditions in Wuxi

Wuxi City has 9 districts affiliated to it, namely Chongan District, Nanchang District, Beitang District, Xishan District, Huishan District, Binghu District, New District, Jiangyin and Yixing (Jiangyin and Yixing are two county-level cities). There were 693 banking outlets in the urban area of Wuxi in 2010 (including ATM). Among them, distribution of outlets of China Construction Bank is as shown in Table 1

Table 1. Distribution of banking outlets of China Construction Bank of Wuxi City

District	CCB	ATM
Chongan District	13	2
Nanchang District	10	7
Beitang District	12	0
Xishan District	22	6
Huishan District	6	10
Binghu District	18	7
New District	6	9
Jiangyin	26	15
Yixing	20	15
Total	133	71

(Note: Aforesaid data is from website of China Construction Bank)

Table 2. Economic and social statistics of Wuxi City in 2010

District	Regional GDP (RMB 100 million)	Regional GDP per capita (RMB)	Population (10, 000)	Land area (m2)	Balance of Saving Deposits in Urban and Rural Areas at year end (RMB 10, 000)
Chongan District	321	77499	22.8854	16.48	3543000.0
Nanchang District	169.1	43400	43.1	23.90	2733120.0
Beitang District	182	54600	37.8490	31.12	2843130.0
Xishan District	402.82	79286	41.4136	399.11	2408100.0
Huishan District	443.54	89423	69.1059	325.12	4573000.0
Binghu District	492.52	93088	68.8965	629.44	5743021.0
New District	958.0	103044	53.6807	218.72	8714000.0
Jiangyin	2000.92	126532	120.71	986.98	6526235.477
Yixing	805.82	64214	107.24	1996.61	5036440.78
Downtown	2986.56	86582	238.36	1643.88	19239978.6
The whole City	5793.30	92166	466.56	4627.47	30802654.86

(Note: Aforesaid data is from Statistical Yearbook of Wuxi (2010))

Jiangyin comes to the top in terms of the quantity of various banking outlets. Jiangyin has secured its top position among Top 100 Counties (Cities) of Economy in China for 9 consecutive years. As a financial and commercial center, Jiangyin has extremely developed economy and high population density. The number of various banking outlets in Jiangyin accounts for 20.5% of the total in Wuxi. On the contrary, banking outlets in Beitang District and Huishan District are relatively limited. As compared with other districts, economy of the two

districts is relatively undeveloped due to the limited scale of enterprises and undeveloped banking business. According to statistics, banking outlets in the two districts are mainly concentrated in commercial center. Furthermore, Wuxi New District has become a top national hi-tech development zone after sustainable development for more than 20 years. Wuxi New District has realized leaping development. It has made great achievements in economic, political and cultural construction. However, as indicated by statistic result, most of banking outlets in Wuxi New District are concentrated at Xinan Street, Jiangxi Street and Hongshan Street.

3.2 Analysis of Outlets of China Construction Bank Wuxi Sub-branch

Distribution of service outlets of China Construction Bank Wuxi Sub-branch is as show in Table 1. General distribution characteristics are stated as follows: It is scarce at outskirts and concentrated in urban area; some counties are lack of service outlets of China Construction Bank. Most of service outlets are distributed along main avenues in the urban area, and are extended to traffic lines in circular shape. According to analysis and study of topological structure of the network as formed by outlets of China Construction Bank, there exist the following problems to the distribution of outlets of China Construction Bank Wuxi Sub-branch:

- **Significant disparity to the spatial distribution of outlets**
  Regional distribution of outlets of China Construction Bank is as shown in Table 1. Viewing from the table, it can be seen that the number of outlets of China Construction Bank enjoys absolute advantages in downtown or urban area. The disparity in Jiangyin and Yixing of developed economy is not significant. However, there exists significant disparity between Chongan District, Beitang District, Binghu District and Xishan District.
- **Significant disparity to the outlet distribution density**
  This paper mainly aims to inquire into the field density of banking outlets. Such indicator can manifest the regional distribution strength of banking services. Viewing from the distribution of field density of the outlets, outlets of China Construction Bank Yixing Sub-branch come to the top in terms of field density with the number of outlets per square meter up to 9.507; field density of outlets in Jiangyin is also relatively high with the number of outlets per square meter up to 4.012. However, field density of outlets in counties at the outskirt of Wuxi is relatively low due to large area and limited banks. Field density of Xishan District and New District is at intermediate level despite of relatively larger area. According to analysis of statistic results as shown in Table 3, there exists significant disparity to the distribution of outlets of China Construction Bank Wuxi Sub-branch.

Table 3. Density distribution of banking outlets of China Construction Bank in Wuxi City

District	CCB
Chongan District	0.183
Nanchang District	0.234
Beitang District	0.432
Xishan District	2.772
Huishan District	3.387
Binghu District	4.196
New District	2.430
Jiangyin	4.012
Yixing	9.507

Outlets of commercial banks in China are arranged in the mode of “Head office---primary branch---secondary branch-sub-branch---small local branch---savings agency---ATM. It is probably due to the influence of arrangement mode of outlets of commercial banks in China. This is a typical yet unreasonable “pyramid” distribution mode. Such distribution is against the general principles for the development of enterprises.

According to conventional thinking, China Construction Bank is always in intimate cooperation with enterprises, which is not directly associated with the township economy. Actually, such viewpoint is against the contemporary economic development status. Taking one village in Jiangyin for instance, it is discovered through statistics that this village is not provided

with any outlet of China Construction Bank despite of its developed economy. This is also one of important reasons for unreasonable distribution of banking outlets.

3.3 Optimization Objective for Integration

The purpose of integration is to realize overlapping between the covered area of each outlet in each district of Wuxi and that of other 4-5 outlets. To satisfy this requirement, it is necessary to take the following integration measures:

The paper proposes to cancel outlets with degree over 5 to prevent wastage of outlet resources.

With regard to outlets with degree below 4, the paper proposes to increase some outlets appropriately; ATM is preferred.

4. Integration of Outlets of China Construction Bank

Distribution of banking outlets is to be in comprehensive consideration of numerous factors, such as social and economic environment. Therefore, integration of outlets is a complicated task. From the point of view of network, this model aims to make use of technologies on complex network to realize reasonable integration of distribution of outlets of China Construction Bank in combination with practical economic conditions in Wuxi.

Firstly, integration of distribution of outlets of China Construction Bank Wuxi Sub-branch has been carried out according to several regulations as stipulated by the proposed model of this paper on integration of banking outlets. 21 outlets have been combined; whereas 17 outlets have been increased; there are altogether 129 outlets following integration; among 17 newly added outlets, there are 15 ATMs. Topological graph for the corresponding network can be obtained through processing and analysis with the help of NetDraw software. Figure 1 and 2 are topological graphs for outlets of China Construction Bank Wuxi Sub-branch before and after integration.

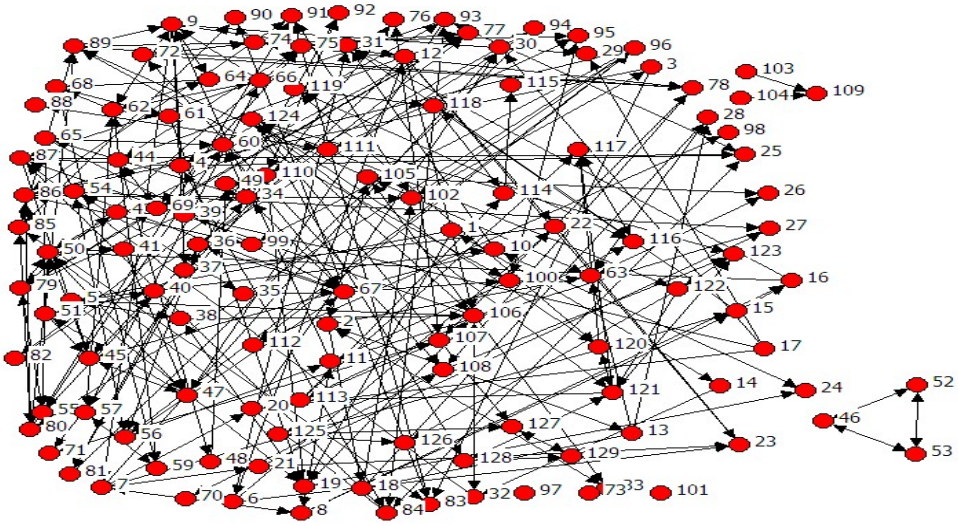

Figure 1. Topological graph of banking outlets of China Construction Bank of Wuxi City before integration

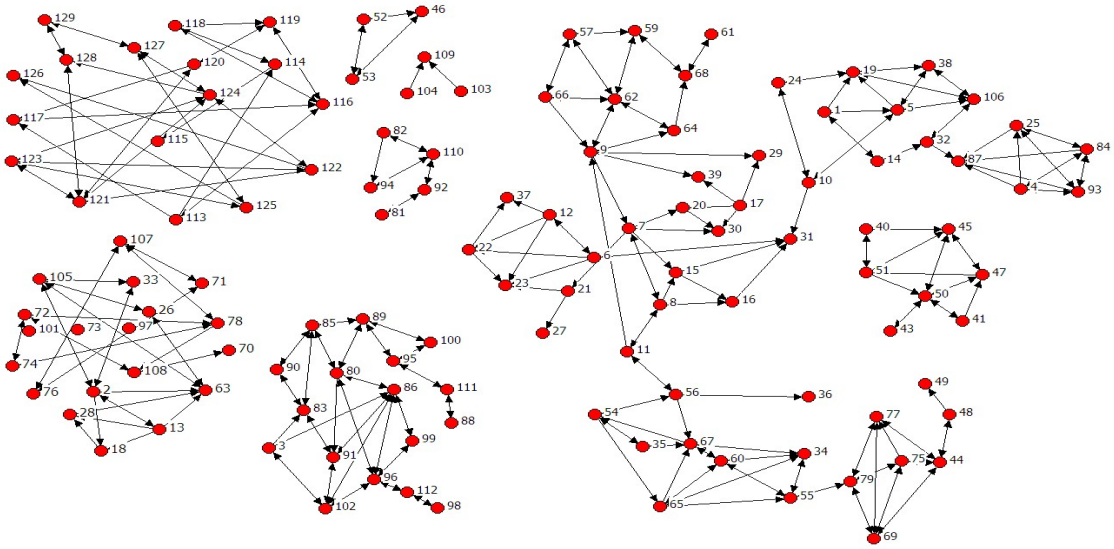

Figure 2. Topological graph of banking outlets of China Construction Bank of Wuxi City after integration

This paper aims to judge if the distribution chart of adjusted network is more reasonable based on the proportion of the reasonable network outlets in the total outlets. It has effectively reflected the reasonability of integrated distribution of outlets. The so called network reasonability ratio refers to the proportion of reasonable outlets in the total outlets. Figure 3 and 4 are topological graphs for the network degree before and after integration.

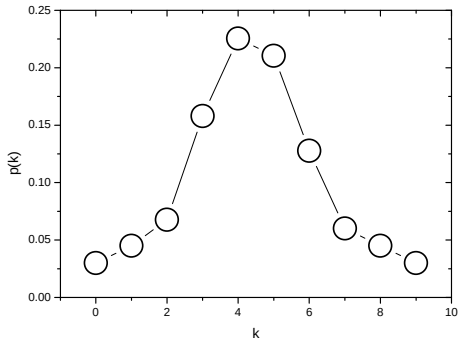

Figure 3. Degree distribution of banking outlets of China Construction Bank of Wuxi City before integration

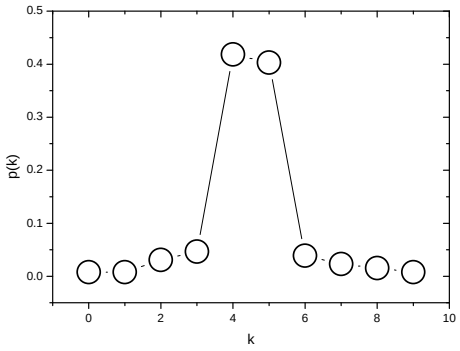

Figure 4. Degree distribution of banking outlets of China Construction Bank of Wuxi City after integration

As discovered through integration, degree of 82.1% outlets is between 4 and 5, which has been increased by 25.8% as compared with that before integration. The paper insists that such banking outlets are reasonable. More importantly, covering radius of several isolated nodes before integration is overlapped with covering radius of other outlets following integration. This has further manifested the reasonability of this model. Taking distribution of outlets of China Construction Bank Wuxi Sub-branch for instance, as discovered by this paper with the integration method proposed by this model that network distribution following integration is more reasonable than that before integration.

5. Conclusion

Reasonability of distribution of banking outlets is determined by the economic and social benefits of the outlets. This paper has established a banking outlet integration model based on technologies on complex network through analysis of 4 factors affecting the distribution of banking outlets, namely population, land area, GDP per capita and saving deposits in urban and rural areas at year end. Meanwhile, this model has been used for analysis, study and integration of distribution of outlets of China Construction Bank Wuxi Sub-branch. As discovered, distribution of outlets following integration is more reasonable. Of course, distribution of banking outlets should be in consideration of other factors, such as local political and geographic conditions, in addition to population, land area, GDP per capita and saving deposits in urban and rural areas at year end. This paper aims to integrate distribution of banking outlets based on the comprehensive analysis of network of banking outlets.

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